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I, KAY WARD, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. PQ 2196 for a patent by MICHAEL JAMES DURACK filed on 13 August 1999.

I further certify that the above application is now proceeding in the name of ULTIMATE MASONRY AUSTRALIA LTD pursuant to the provisions of Section 113 of the Patents Act 1990.

WITNESS my hand this
Thirtieth day of August 2000

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METHOD AND APPARATUS FOR MOULDING PASTES AND SLURRIES

This invention is concerned with improvements in moulded cementitious articles and particularly, although not exclusively to a method and apparatus for moulding masonry articles.

It is well understood that mixtures of particulate materials and water or other liquid can be dried or dewatered using vacuum applied behind a filter membrane placed between the material to be so dried and the vacuum.

The process is normally used to extract the liquid from the solid so that either the solid or liquid is recovered for further processing or sale.

In the manufacture of masonry articles with a cementitious composition, a compromise must be made in determining the water content of such a composition.

To maximize the strength of the masonry article, only sufficient water to hydrate the cement powder should be added to the composition. Invariably this results in a relatively dry mixture which is difficult to mix thoroughly in a conventional concrete mixer and this dry mixture is difficult to handle in a mould due to its stiff non-flowable nature.

While mixing and handling of cementitious compositions is assisted by adding an excess of water to produce a flowable paste or slurry, the strength of the resultant cured product is substantially lessened by shrink cracking and the like.

It is also well understood that the qualities of some materials such as concrete are improved by having them undergo this process. Dewatering of concrete can remove water from concrete after placing so as to lower the water cement ratio which will normally have the effect of increasing the rate of set of the concrete and/or improving properties such as strength or water-tightness. Dewatering of concrete is carried out using either applied pressure directly, or indirectly by applying vacuum to the to of the concrete via simple perforated screen.

Typically, a concrete building panel can be dewatered in a horizontal mould having a perforated screen floor and a perforated screen mould top. A filter medium of paper or fabric is located between the upper and lower screens and the upper and lower faces of the panel.

After filling the mould with a flowable concrete slurry, a mechanical or hydraulic force is applied to the upper screen to force excess water out of the concrete mass to produce a moulded article stiff enough to remove from the mould.

Vacuum dewatering utilizes a similar mould structure encased in a flexible membrane enclosure. When the interior of the membrane enclosure is evacuated, atmospheric pressure applied to the upper screen surface effects dewatering in a manner similar to the mechanical or hydraulic process described above.

Dewatering systems operating in this manner are difficult to operate and can normally only produce simple flat or flat-sided

components. As the water is drawn out of the article being dewatered the volume of the article will decrease. It is not possible to mould a three dimensional shape without using a mould that is designed to "shrink" while the dewatering or compacting process is underway.

It is an aim of this invention to provide an improved method and apparatus to remove the water from a moulded article in such a way that the shape and/or volume of the article remains the same throughout the dewatering process.

According to one aspect of the invention, there is provided a method of dewatering cementitious articles in a mould, said method comprising the steps of:-

filling a mould having one or more apertured walls with a flowable paste or slurry of cementitious material; and,

creating a pressure gradient between an inner region of cementitious material in said mould and an outer region of said cementitious material in said mould whereby excess water is expressed from said cementitious material by a volumetric expansion within said cementitious material.

If required the volumetric expansion may be effected by a mechanical element in said mould.

Suitably, the mechanical element may comprise one or more expandable core members.

Alternatively the mechanical element may comprise one or more

extendable projections associated with at least one inner face of said mould.

Preferably, the volumetric expansion is effected by entrained air in said cementitious material.

Suitably, said pressure gradient is effected by introducing said cementitious material into the interior of said mould under superatmospheric pressure and exposing the exterior of said mould to a pressure less than said superatmospheric pressure.

Suitably, said pressure less than said superatmospheric pressure is sub-atmospheric pressure.

If required said one or more apertured walls may comprise a screen member.

Preferably said screen member comprises a wedge wire sieve.

According to another aspect of the invention there is provided an apparatus for the manufacture of moulded cementitious composition, said apparatus comprising:-

a hollow mould having one or more apertured walls;

an inlet port for the introduction of a flowable paste or slurry of cementitious material;

an outlet port for ejection of articles formed within said mould; and,

means to create, in use, a pressure gradient between an inner region of cementitious material in said mould and an outer region of said cementitious material in said mould whereby excess water is expressed

from said cementitious material by a volumetric expansion within said cementitious material.

If required said means to create a pressure gradient may comprise a mechanical element in said mould.

The mechanical element may comprise one or more extendable projections associated with at least one inner face of said mould.

Alternatively the mechanical element may comprise one or more expandable core members.

Said means to create a pressure gradient may comprise pump means to introduce said cementitious material into the interior of the said mould under superatmospheric pressure.

Said means to create a pressure gradient may include means to form a sub-atmospheric pressure at the exterior of said mould.

If required, said one or more apertured walls may comprise a screen member.

Suitably, said screen member comprises a wedge wire sieve.

According to a further aspect of the invention there is provided a moulded cementitious article whenever produced according to the aforesaid method and/or whenever produced with the aforesaid apparatus.

Vacuum dewatering systems applied to concrete have previously been used to enhance material properties after setting. However the material properties of fresh dewatered concrete are also changed and it is

a further aim of this invention to use this change to advantage.

When concrete has been dewatered using this method the capillary channels between the fine particles are drawn down to a thickness, that is as small as they need to be to resist the vacuum pressure applied to them. If concrete is dewatered using pressure, the material is simply compressed until the internal aggregates lock up and resist any further compaction. The capillaries can remain "full" of water and not actually drained.

Concrete drained using vacuum or pressure acting directly on the capillaries can exhibit tensile strengths, immediately after draining which are consistent with the presence of an internal binding force roughly equivalent to the vacuum pressure applied to drain it. This means that concrete drained in this way, under a vacuum of around 50% atmosphere will exhibit a tensile strength of around 0.04 to 0.08 Mpa. Concrete drained using pressure (even when much higher than 50% atmospheric pressure) will not exhibit such a high tensile strength.

The final properties of concrete drained in this way are also improved as the thickness of the final capillary channels are more uniform and the remaining water is uniformly distributed throughout the mix.

In this way it is possible to de-water light weight concrete that contains flexible pockets of air or flexible aggregate without collapsing the material itself.

It is well understood that it is possible to entrain large quantities of

air in cement and sand mixtures and in cement and flyash mixtures. Quantities of air as high as 80% are possible.

These mixtures, when in their wet state are highly liquid, and are impossible to shape unless they are cast into moulds and are allowed to set over a period of several hours. Any attempt to use pressure or vibration will simply collapse them and so the "normal" block making techniques employed for dense concrete are unsuitable as are the normal "pressure" or "press" type vacuum moulding techniques.

There are techniques that employ wire cutting of partly set aerated concrete to produce solid modular blocks in an industrialized manner but there are no aerated concrete products that have been made in a rapid moulding process. This makes it very difficult to produce hollow light weight blocks out of aerated concrete and the inventor is unaware of any products make of aerated light weight concrete that are hollow. This method is also unsuitable for use with large particles or fibres of either mineral or organic origin. It is generally only employed using maximum particle sizes of around 1mm.

In order that the various aspects of the invention may be more fully understood and put into practical effect, preferred embodiments will now be described with reference to the accompanying drawing.

When aerated light weight concrete is placed in a sieve lined mould it is possible to de-water the concrete in a way that does not remove the entrained air and will leave the concrete stiff enough to de-mould after a

short period of time.

It is advantageous to pump the light weight concrete into the mould under pressure as this results in greater dimensional accuracy and gives the ability to control the product density to a greater extent.

A typical mould arrangement for the making of a 190mm x 190mm x 390mm hollow block consists of:

- ◊ A sieve lined box 190 x 190 x 390. Attached to a sieve lined lid, wherein the sieve is arranged in the shape of the plan view of the block.
- ◊ A pair of sieve lined core formers approximately 190 x 130 x 140 attached to a base similar in layout tot eh lid but including a hole through which concrete can be injected.
- ◊ The box and lid is arranged to fit over the base and to be able to be raised and lowered on guides arranged on either side. The lid can be held in place under a force provided by a hydraulic ram mounted on a frame over the top.
- ◊ Each facet of the mould is provided with a spigot connection for attachment to a vacuum source.
- ◊ The sieve liners are typically wedge wire screens with an aperture of less than 200 microns.
- ◊ The base is provided with a valve which can be opened to allow the passage of concrete into the mould cavity via the hole in the base. The valve can be closed once the mould is

full.

- ◊ The valve is connected to a supply of concrete at pressure.

In operation the procedure is follows:

- ◊ The mould is closed using the hydraulic ram.
- ◊ The valve in the base is opened allowing concrete to fill the mould.
- ◊ The concrete fills the mould and as the pumping continues the entrained air is reduced in volume as the pressure builds up in the mould and more material can enter the mould.
- ◊ Water starts to leave the material being forced out by the internal air pressure.
- ◊ As the water leaves, the entrained air bubbles expand and compensate for the loss in volume caused by the departing water.
- ◊ The concrete is allowed to “drain” under the pressure of the compressed air within the aerated concrete for 1 to 2 seconds. Water starts to drain out of the material near the sieve faces and into the cavities behind the screens.
- ◊ The vacuum is applied to the lid, base, outer wall and then inner core, for around 15 seconds. More water drains out of the material, and the entrained air can expand further to compensate for the lost volume. As it approaches a “dry” state air from the enclosed bubbles follows its. The larger

bubbles are the first to "leak" in this way as the internal pressure within them is higher than that present in the small bubbles. Ultimately only small bubbles remain. It is the initial proportion of small bubbles that appears to control the final density.

- ◊ The vacuum within the core is turned off. This causes a slight shrinking back of the material near the core, as the space within the mould returns to atmospheric pressure.
- ◊ The vacuum is released from the floor and the box and lid is raised to a point slightly above the core sieves.
- ◊ A "pallet" is inserted in under the raised block and the vacuum on the walls and finally the lid is turned off.
- ◊ The block drops out of the mould, the mould is raised 200mm and the block is removed.

Figure 1 represents the abovementioned arrangement in schematic form.

In this figure, the upper part 1 of the mould which engages onto the lower part 2. The line 12 is the line along which the two mould parts split as the "block" is ejected by the ejection rod 10, which is connected to ejection plat 13.

The mould is clamped using clamp 11. Concrete is pumped into the mould via the supply pipe 5.

Wedge wire sieves 3 line the walls of the mould and seal off the

cavities 4 behind them. When the mould is full the cavities 4 are evacuated and the water is drained out via vacuum lines 6, 7, 8 & 9.

The vacuum is released, the upper part 1 of the mould is raised and the "block" is ejected by the ejection plate.

As an alternative the block may be ejected by applying a positive air pressure to the void 4 behind the ejection plate 13 via the vacuum line 9.

It is preferable to first raise the upper part of the mould 1 and the ejector plate 13 above the base 2 so that a receiving table can be inserted above the part line 12 to receive the block, before the block is ejected. Once the table is inserted the mould can be raised further while the ejector plate or air pressure pushes it out. The receiving table can be removed with the block on it after the mould is fully raised to the upper position.

Many other configurations of this arrangement can be made including but not limited to - larger blocks, solid blocks, panels, and completely hollow blocks. Anyone skilled in the art of making these sorts of things would see many other possibilities.

It is also possible to use this type of arrangement to produce extruded concrete sections either on flat or on edge with or without holes.

Many combinations of both sieve lined cores and non sieve lined (plain) cores can be arranged for specific requirements. Internal bubbles or voids, can be caused to be created within the products during vacuum

de-watering, by introducing perforated pins into the centre of the wet concrete. These pins are connected to valves that can be alternately connected to vacuum, or atmosphere, or pressure and will allow small bubbles to develop within the material while it is being vacuumed so as to maintain dimensional accuracy of the outer surface.

It should be noted, that the releasing of the block or other product from the mould after completion of the de-watering process, is achieved because three things happen simultaneously.

- ◊ When the material has "dried" the capillaries between particles have drawn the material below the upper faces of the larger surface particles and there is no longer any large contact of water with the surface of the wedge wire. There can no longer be any suction of any smooth surface with the body of concrete.
- ◊ The wedge wire screen allows the material to breathe so that "suction" is further reduced.
- ◊ The breathing ability of the wire screen allows the concrete to "shrink" slightly off the face of the wire causing a gap to develop between the concrete and the wire allowing for almost frictionless release of the product.

It is also possible to arrange the releasing sequence, so that the shrinking is reduced to such a level, that the concrete is still in contact with the sieves. The releasing can then be achieved by washing the back

of the screen with water so as to cause a slipper slurry to develop on the interface, and so release the block.

If concrete without entrained air is pumped into this type of mould arrangement a similar de-watering process will occur with the loss in volume caused by the departing water compensated by the entry of fresh "mobile" material. If no air is present it is not possible to fully drain the moulded material as the water will not leave if there is nothing left to replace it no matter what vacuum is applied.

In practice it is very difficult to make concrete mixes without entraining air and so it would appear to work without any special effort to include air. This is because the process will work with very small quantities of air present.

It must be remembered that if a concrete mixture is pumped into the mould at 2 atmospheres and contains as little as 20 litres per cubic metre of entrained air, at this pressure, when the vacuum is applied down to 25% atmospheric pressure, this air will increase to around 160 litres in volume. Typically the removal of 50 to 100 litres of water from a "mobile" concrete mix will cause it to stiffen to a very firm state.

It also is an aim of this invention to create a moulding method for moulding air entrained concrete and similar materials that can be used to mould very mobile or wet slurries in a porous mould. The mould being designed, so that as entrapped air expands within the slurry, either because it is under pressure or because the mould has vacuum applied to

it, it forces water through the porous walls of the mould to such an extent that the slurry “sets” into a rigid form.

It is a further aim to apply the same principle to mould similar materials containing very little or no air by expanding or inserting “cores” into a porous mould as the water or liquid is forced out of the mould by the pressure applied by the expanding or entering “cores”.

The process can be applied to many different mixtures of particles and liquids including many industrial waste materials that contain large quantities of water. It can also be applied to mixtures containing fibre material or compressible particles.

It can be applied to conventional filter press applications where an increase in air content will cause a more rapid departure of the liquid and perhaps a more rigid “cake” because of a more complete removal of water.

FIG 1